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Seed Potato Upgradation and Post-Harvest Management

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Plant Protection & Seed Production

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2 LIST OF ACRONYMS

ASF	Agribusiness Support Fund
CIP	International Potato Center
CNFA	Non-governmental Organization
FAO	Food and Agriculture Organization-ONU
Ha.	Hectare(s) = 10,000 m2 or 2.47 acres)
Mmt	Million Metric Tons
MT	Metric Ton (1,000 kg)
NARC	National Agriculture Research Center
PVY	Potato Virus Y
RH	Relative Humidity
STTA	Short Term Technical Assistance
TAP	The Agribusiness Project
USAID	United States Agency for International Development
USDA	United States Department of Agriculture

3 EXECUTIVE SUMMARY

The general objective of this assignment was to develop in Pakistan an assessment of the value chain of the seed potato up-gradation and the evaluation of the seed potato post-harvest technologies and management.

Due to the lack of potatoes in the field and to security reasons, only part of this assignment was possible to carry on. To have a realistic evaluation of the potato seed quality planted by farmers, it is necessary to conduct a survey when potatoes are in the fields. There is also a need to visit and analyze *in situ*, the seed potato production advantages in the northern areas.

Several meetings were conducted with farmers producing seeds, importers of potato seed, different government agencies (Federal and Provincial), new seed companies trying to produce high quality seed and other stakeholders in Islamabad, Lahore and Abbottabad.

Previous intervention reports on the potato production have suggested focusing mainly on upgrading seed production, as this is one of the principal yield constraints. This assignment has clearly indicated that the principal constraints in the production of high quality potato seed in the country are the ones listed below:

Constraints:

1. The seed production and the whole potato production is highly fragmented and not professionally conducted, e.g. different production season, different agro-ecological places, high technological gap among producers, lack of support from Government agencies, etc.
2. Of the total seed needed in the country, less than 1% is produced locally.
3. There is not a seed production system in the country, only local multiplication of imported seed.
4. Imported seed is multiplied up to seven times without the implementation and supervision of proper certification protocols. This may account for the great gap between the yield potential of the variety and the actual yield from farmers´ fields.
5. Although there was a certification protocol approved several years ago, there is not a clear definition on the duties and responsibilities of the government institutions that should be involved in a certification scheme, variety importations and evaluations, and registration.
6. Facilities for production of high quality seed developed in the 80s and 90s by international development projects are in poor condition; production technologies have not been updated and financial support from the government are minimum.
7. It is not clear which institution(s) provides oversight for evaluations and development of procedures to import new potato varieties into the country, since the Federal Seed Certification Department, Plant Quarantine Department and National Potato Programme (NARC) are all involved.
8. There is lack of training and updates on seed production technologies at all levels, e.g. seed farmers, seed importers, extension and certification departments.
9. There is a need for a better and effective organization of seed multipliers from the northern areas, e.g. Gilgit and NWFP. Punjab seed multipliers have lost trust in the farmers from the

northern areas since the best and freshest potatoes are sold to the highest bidder at harvest due to high demand.

Interventions and Recommendations

Recommended interventions can be divided into the five main objectives:

1. To fully complete the assignment and have a realistic view of the seed production situation, it is needed to: a) conduct a field survey at the farm level to see the multiplication of seeds in order to evaluate seed quality and the different stages of the multiplication process, and b) at the same time, conduct a survey on harvest and post-harvest procedures and tuber management. The best time in the Punjab region is one month before harvest between January and February (Short-Term Planning). The occurrence, dissemination, importance and the causal organism of the potato scab must be determined, and an integrated control management approach developed.

2. To develop a Training Program, which should include the government agencies involved in seed certification, the farmers multiplying imported seed, and the companies producing high quality seed in Pakistan. This should be a 2-day workshop, which includes one day spent in the classroom and one day spent on field training. It should be held at the main potato producing areas in Punjab. Training can be held during implementation of Recommendation 1. Farmers from the northern areas should also be included in this training since at that time in the fall, there are no potatoes in that area in the fields. (Short-Term Planning).

3. Companies producing high quality seed and seed importing farmers should establish a formal agreement with seed farmers from the northern areas to multiply their seed in those areas at high altitude to avoid seed degeneration due to diseases. ASF could play an important role in getting these two parties together, with the assistance of the Agha Khan Foundation which is currently trying to develop and group farmers for this purpose. Mr. Abdul Khabir, RPM from ASF, has ample experience in potato production and a wide knowledge of the region. Local seed companies such as Hazara Agriculture Research Center and similar ones with IN-VITRO facilities should also be included in this joint venture (Mid-Term Planning).

4. Efforts should be made by ASF to coordinate meetings between the different government agencies involved in potato seed certification and evaluation of new potato varieties imported into the country in order to clearly define the role, duties and responsibilities of each one. If this is not clearly established and seed certification is not enforced, then new companies trying to produce high quality seeds will not be competitive with companies importing seed. Performing a series of field multiplications without any seed potato certification enforcement will not assure farmers the use of high quality seed (Mid-Term Planning).

5. Cellars for potato seed storage in the northern regions of Pakistan should be promoted and more cellars constructed, especially for the group of farmers that will formally multiply seed for the Punjab Companies producing seeds (Long-Term Planning).

4 BACKGROUND

World Potato Production

Until recently, potatoes ranked fourth in the world after wheat, rice and maize in importance as a human food crop. However, with large and increasing amounts of maize being diverted to production of biodiesel, potatoes have escalated up to third place. More than a billion people worldwide eat potatoes every day. According to 2010-2011 statistics provided by FAO, CIP, Agrimarkets Inc. and others, the current estimated potato production in the world is close to 340 million metric tons (Mmt) produced in about 18 million hectares with an average yield of 17.7 tons/hectare.

The largest potato producing region is Asia with close to 128 Mmt. The production from Latin America is about 16 Mmt from approximately 1 million hectares and with an average yield of 18 tons/ha. By far, China is the largest potato producer in the world with about 68 Mmt, followed by Russia with 37 Mmt, India with 28 Mmt and USA with 20 Mmt. Europe has the largest annual consumption per capita (88 Kg), followed by USA (60 Kg), Asia (24 Kg), Latin America (21 Kg) and Africa (14 Kg).

REGION	Harvested Area (Ha x 1,000)	Production (tons x 1,000)	Average Yield (tons per Ha)
Africa	1,592	17,960	11.5
Asia & Oceania	8,140	127,400	15.7
Europe	6,995	126,540	18.4
Latin America	1,050	17,500	17.5
North America	600	24,640	40.8

Source: CIP Potato Facts 2012/Faostat

The global expansion in potato production, which has doubled in the past 20 years, far exceeds those of higher ranked crops such as maize and wheat. At the same time, potato production in the traditional potato growing regions of Europe has been steadily declining, but this decline has been more than offset by simultaneous rapid growth in Asia, Africa and Latin America.

Today, more than one half of global potato production originates from developing and least developed countries, up from a share of just 11 percent in 1960. Despite this impressive increase in total production, potato yields in non-traditional potato producing countries are still far below their agro-ecological potential. Crop husbandry is still poor, because farmers are not fully aware of good agricultural practices for this newly introduced crop. Potato yields also suffer severely due to the use of inappropriate varieties, lack of high quality seed and post-harvest losses.

Until recently, in many developing and least developed countries, the potato was relatively unknown and mostly regarded as a subsistence crop. However, today the market is expanding rapidly as potatoes are increasingly popular as a source of affordable food for growing urban populations. In addition, a more affluent middle class has developed a preference for potatoes in processed forms such as fries and crisps. This growing domestic market presents a valuable opportunity for smallholder farmers. Potatoes have a high per area production potential, can be stored relatively easily and, most importantly, can be used as a staple food crop for household consumption, food security, or sold as a cash crop.

The trends indicate that the most rapid growth in potato production in terms of percentage will be in developing countries. The CIP model forecasts that annual growth in potato consumption will be less than 1% in developed countries, but nearly to 3% in developing countries. The two most populated countries in the world -China and India- are expected to increase annual potato consumption in 2.8 % and 3.8 %, respectively.

Pakistan Potato Production

Potatoes were introduced in this part of the world in the 17th century, initially by Portuguese sailors, and cultivation was later expanded under the British colonial rule in the 19th century.

At the time of independence, around 3,000 hectares (ha) were being cultivated, which has expanded significantly, especially during the past 25 years. The latest statistics available from 2008-2009 (Agricultural Statistics of Pakistan) indicates that there are approximately 144,000 ha of potatoes, with a total production of about 2.9 Mmt (farmers in Punjab say that real production is higher than 3.5 Mmt) with an average yield of 17.0 tons/ha. Potatoes are ranked third as a food supply crop. Close to 85% of the potatoes are consumed as fresh potatoes. Average estimated per capita consumption in Pakistan is about 12.5 kg.

Punjab, with a production area close to 90%, is the main potato producing region in the country, followed by the NWFP (6%), Balochistan (3%) and Sindh (1%). Potatoes are planted and harvested three times a year, depending on the region of the country (see Appendix 1 for main areas of production.)

Season	% of Production	Planting Dates	Harvest Dates
Autumn	75-80	Sept - Oct	Jan – Feb
Summer	10-15	Mar - Apr	Aug – Oct
Spring	10	Jan - Feb	Apr – May

Since the potato crop in Pakistan is almost entirely dependent on irrigation, precipitation does not determine the cropping calendar. The autumn crop is by far the most important, accounting for about 75-80% of total production, followed by spring with about 10-15%, and summer with about 10%. The spring crop has been declining since 1995 mainly because it provides a shorter season for tuber bulking and is more susceptible to aphid infestation and related diseases;

however, spring is when the imported seed is planted. (See Appendix 2 for Climatic Conditions in Pakistan).

Although Pakistan is a large potato producing country, it has very limited storage and processing facilities. The combination of inadequate storage facilities and a poor developed processing industry leads to volatility in prices.

The quality of potatoes produced in Pakistan is quite acceptable and this is supported by the fact that the country normally exports fresh potatoes to some countries in the region. The main clients are Russia, Sri Lanka, Iran, Afghanistan and Hong Kong (Min. of Commerce, Pakistan Horticulture D&E company). The export to Russia in the 2010-2011 marketing season was 125,000 tons. In early 2013, Pakistan shipped 50,000 tons to Iran (Inpaper Magazine). During 2012, due to exportation suspension activities, large quantities of potatoes (close to 600,000 tons) were left in warehouses and in the fields without proper storage(see Appendix 3 for Potato Exports.)

A critical constraint to meet increasing demand and population growth is the availability of high quality seed, from adapted varieties with acceptable levels of resistance to pest and diseases. The cost of high quality seed is about 35-40% of the total cost of production in Pakistan. Certified seed production is limited and faces technical, economical and managerial problems. Most farmers rely on seed sources of doubtful phytosanitary conditions or on their own seed production, for which most of them do not have the proper skills and technical knowledge of production.

Data available until 2004 indicates that the amount of local and imported certified seed used never exceeded 3.0% of the total seed requirements in the country.

YEAR	Total Seed Requirements (Tons)	Imported Seed (Tons)	Certified Local & Imported Seed (%)	Locally Produced Seed (%)
1987-88	155,100	1,238	0.8	99.2
1988-89	170,000	4,507	2.6	97.4
1989-90	213,000	597	0.3	99.7
1990-91	194,000	495	0.2	99.8
1991-92	213,600	1,706	0.8	99.2
1992-93	213,600	1,000	0.5	99.5
1993-94	241,260	969	0.4	99.6

Source: Pak-Swiss Potato Development Project, NARC, Islamabad (A. Hussain & K. Farooq)

5 OVERVIEW OF POTATO SEED PRODUCTION

5.1 The Reasons for a Special System

As compared with most other important food crops (wheat, maize, rice, beans, sunflower, etc.), potatoes do not multiply commercially by seed (sexual seed), but they multiply by vegetative means. This means that a part of the plant is used to reproduce it. Most potato plant parts are able to produce roots and to develop into a new plant, e.g. stem pieces, sprouts, leaves, stolons. This provides an easy system for multiplying a crop, but at the same time is extremely dangerous because most diseases affecting potatoes are transmitted by the tubers.

Potato yields are affected by several factors. Quality seed is one of the most important factors. Studies completed in several countries and different agro-ecological conditions indicate that the use of good quality seed produced yields 30-50% higher when compared to farmer´s seed. Reductions could be higher if tubers are infected by diseases that drastically reduce yields such as late blight, bacterial wilt, potato virus Y (PVY) and others.

5.2 The Seed Production Systems

To maintain genetic identity of the varieties and clean stocks to produce healthy and high quality seed requires the use of several biological technologies and special physical facilities, e.g. virus testing labs, IN-VITRO facilities, rapid multiplication schemes, and high standards of sanitary conditions. As a consequence, potato seed production programs or units are highly demanding on financial resources and qualified technical personnel. It is normally stated that potato seed tubers are:

- Slow to multiply: from IN-VITRO stocks to certified seed may take 5-7 years
- Expensive: time, labor and physical resources needed
- Prone to be contaminated by pests and diseases
- Must be stored correctly: cold stores, diffused light rustic stores
- Must be planted at the right physiological age: dormancy, sprouting

Even though each seed potato program from country to country is different, they all essentially follow the same central scheme for seed production:

- Maintenance of clean stocks in IN-VITRO facilities (Nuclear stocks of varieties)
- Production of mini-tubers under restricted sanitary conditions within screen-houses (G0)
- First field multiplication performed under highly restricted sanitary regulations (Elite 1)
- Additional multiplications, a sequence of one to three more, performed under sanitary regulations (Elite 2, Elite 3, Elite 4)
- Further multiplication performed by specialized seed producing institutions to produce foundation and certified seeds. Production of certified seed to be sold to farmers for production of fresh-table potatoes.

The above sequence may have several variations according to the program, but in general these are the main steps. All of them emphasize keeping and producing healthy seed, free of most diseases and with high standards on their agronomic traits, e.g. color, shape, etc., according to each variety (genetic purity). In countries that have a highly developed seed production system (e.g. Canada, Australia) farmers will normally use Elite 3 or 4 for table potato production. Countries that have to import seed potatoes normally will use certified seed.

5.3 Comparison of Four Different Seed Production Systems

SEED CATEGORY-YEAR	CANADA	INDONESIA	CHILE	AUSTRALIA
IN-VITRO- Year 1	**Yes**	**Yes**	**yes**	**Yes**
Nuclear-Plantlets-Year 1	**Yes**	**Yes**	**yes**	**Yes**
Pre-Elite (Minitubers)-Year 1	**Yes**	**Yes**	**yes**	**Yes**
Elite 1- Year 2	**Yes**	**G0**	**Pre-basic**	**G0**
Elite 2- Year 3	**Yes**	**G1**	**Basic**	**G1**
Elite 3- Year 4	**Yes**	**G2**	**C1**	**G2**
Elite 4- Year 5	**Yes**	**G3**	**C2**	**G3**
Foundation- Year 6	**Yes**	**G4**	**C3**	**G4**
Certified- Year 7	**Yes**	**Yes**	**yes**	**Yes**

Although China is the largest potato producer in the world, close to 99.5% is consumed in the country. The largest seed producer and exporter is The Netherlands, which controls close to 75% of the seed market with a total revenue of approximately USD 3.5 billion per year. Its main clients are Russia, China, India, Africa and Latin America.

Quality indicators of seed have two dimensions: the biological attributes (biological quality) and the appearance attributes (commercial quality). Biological quality is crucial for productivity, whereas commercial quality affects seed price. The biological quality includes two main aspects: 1) the level of disease infection, and 2) physiological age of seed tubers.

5.4 The "Informal" Seed System

Under the informal seed system, farmers keep part of their seasonal production as seed for the next planting season. It is common for farmers to keep the smallest tubers that cannot be commercialized as seed. Some farmers, with some rudimentary knowledge of seed production become seed producers. However, in all of these cases, there is neither an official sanitary control over the crop nor a certified quality system. In those countries with high altitude locations, it is a normal practice for those farmers to become " seed producers". Viral infection, which often accumulates over time and can seriously limit potential yields, is generally lower at higher altitudes. In the plains areas where most potatoes are grown, populations of aphids, which transmit many viral strains, are generally heavier during the spring cropping seasons. Seed from higher altitude areas might therefore be used to inject "fresh" planting material into the system.

5.5 The "Formal" Seed System

The formal system refers to seed tubers produced and distributed by state-sponsored institutions, with involvement of the private sector. Plants and tubers have generally been subject to an inspection process intended to ensure that the seed is of the variety claimed, with low incidence of disease or pest infestation, and otherwise viable. Such seed is often referred to as "certified seed," although the precise definition of this term is locally variable. Seed produced via the formal system is far more expensive than seed available via the informal system, but hopefully proves itself a positive investment with increased yields over several generations.

In Pakistan, several public-sector institutions (National Potato Program, Hazara Research Center, etc.) as well as private ones (PPEPSICO, Punjab Seed Corporation, etc.)have been involved in the effort to establish and maintain facilities for rapid multiplication and dissemination of seed tubers. The percentage of Pakistan's potato crop planted with certified seed is very small. However, this small amount belies the potential impact, as some farmers purchase certified seed which they multiply and sell as higher quality seed tubers at higher prices for several years, perhaps three or four, until stocks are renewed with another purchase of certified seed.

6 CURRENT SEED POTATO PRODUCTION IN PAKISTAN

Pakistan is a large potato producing country yet it has very limited adequate storage and processing facilities. The combination of inadequate storage facilities and an underdeveloped processing industry leads to volatility in prices as not all production excess can be stored or processed for consumption during the off season.

Several studies and reports on the potato production in Pakistan (1975 to 2013) indicates that, one of the principal constraints in production is the lack of certified high quality seed, followed by the lack of storage facilities, a restricted gene pool (few varieties in the market) and the lack of financial support for farm inputs and a proper credit system for farmers.

Due to the complexity of the seed production and seed flows from different geographical areas and in different production seasons, the assessment and comments derived from this consultancy have been grouped in the chapters mentioned below. Security restrictions to travel to some key production areas in the north of the country and the absence of potatoes in the fields at the time of this visit have restricted and probably affected the production of a more ample and deep assessment of the current seed potato situation in Pakistan.

6.1 Seed Potato Production in the Punjab

***Analysis of the seed system in place*.** As mentioned before, this region produces almost 90% of the potatoes of Pakistan, with some farmers planting over 400 ha. per year.

There are two clear seed potato production systems in the Punjab plains, which can be summarized as follows:

1. The main seed production system currently account for almost 99% of the seed planted in the Punjab. The system is a ***raw multiplication*** of imported seed. I have named it a raw multiplication, because large farmers import seed mainly from The Netherlands, multiply this seed 2 to 3 times and sell the seed to other small seed farmers, who multiply them another 2 to 3 times.

   All of these multiplications are done without any official seed certification protocols, so it can hardly be named SEED. This raw multiplication is without any doubt the main reason why farmers producing table potatoes are getting small yields between 14-18 tons/ha with varieties such as Asterix, Sante, Kuroda, whose yield potential using high quality seed, should be no less than 35-45 tons/ha.

2. There are a few seed companies, some of which have been trying to develop a seed production system from ***tissue culture labs*** for only a couple of years. These private companies are looking into the future of the seed potato business but in total, produce less than 0.5% of the seed required for Punjab. The companies are:

- Zamindara Seed Corporation
- Aeroponic Pozazo Seed
- Punjab Seed Corporation
- PEPSICO International

They all face the challenge of finding proper places to multiply their high quality seed (from minitubers to certified seed) in order to avoid virus infections and the occurrence of other diseases.

PEPSICO is a special case, because they have their own varieties for processing, carefully select their farmers, and provide good field production training and high quality seed. They indicated that one of the problems, observed recently, is the significant increase of scabs. Although it is a disease that does not significantly affect yields, it drastically affects the quality of tubers and its processing. The type of scab has to be confirmed.

The third important item in the seed production/multiplication cycle is that the imported seed is planted in the spring season and is, therefore, highly susceptible to infection by viruses as the aphid population reaches its peak at this time of the year. Some of these new seed production companies, as well as PEPSICO, are looking for locations, mainly in the northern highlands, where they can multiply their seed with less risk of being infected by viruses.

As a result of meetings with government personnel from the Extension, Seed Certification and the Agriculture Marketing Board, the following items are important to mention:

- All of them have a rather sporadic intervention in the seed production/multiplication process in the Punjab region.
- They claim that they have very limited resources available to perform any significant intervention.
- Currently, their main constraint besides limited resources is the need for technical training on seed production subjects, e.g. certification protocols, field identification of main pest and diseases, concepts such as rouging, seed plot techniques, etc.

It is my personal believe that some large farmers importing potato seed, mainly from The Netherlands, would like the system to remain as it is in the present. To enforce seed certification may result in large amounts of potatoes being rejected commercially as seed.

Almost 99% of the varieties imported are from The Netherlands. This may present the problem of a very narrow gene pool being present and low diversification in terms of disease resistance to several pathogens, especially viruses such as PVY, PVX, PLRV, and also frost resistance. Efforts should be made to import varieties form other countries, especially France, USA and Canada to have a more diverse gene pool in the country.

6.2 Seed Potato Production in the Northern Areas

***Analysis of the current seed production systems*.** As a result of a visit to the Abbottabad area, a meeting with potato producers and technical personnel from the Gilgit-Baltistan regions, the following observations are important to mention:

1. The collaborative research agreements in the past (1980-2005) with institutions, such as The International Potato Center, GTZ, FAO and the Swiss Potato Development Project, in this region of the country developed the following seed producing units including tissue culture Labs (see Appendix 4 for Minituber capacity in the country until 2004):

    - Hazara Agriculture Research Station in Abbottabad (potential capacity to produce 200,000 Minitubers)
    - Gilgit tissue culture lab in Gilgit (potential capacity to produce 200,000 Minitubers)
    - Tissue culture lab at Skardu (potential capacity to produce 50,000 Minitubers)
    - Tissue culture lab at Ghizer (potential capacity to produce 50,000 Minitubers)

    The actual production of all these seed producing units is less than 10% of their potential. The main factor for the great erosion of these facilities is the lack of proper financial support from the Government (Federal / Provincial) although they still have qualified personnel.

    Hazara Agriculture Research Center (Ex-Potato Center) is presently producing 8,000 minitubers a year using a very old production system. They plant their minitubers in places like Batakundi, Mansehra, and Sharan and currently produce 100 Tons of high quality seed. With the proper financial support they could produce up to 8,000 MT of seed. Local farmers lack proper training on post-harvest handling of tubers and also need more cellars to store seed tubers from five to seven months. Seed could be sold in the Punjab region above 40-50 Rs. Per kilogram.

2. With so many good conditions to produce and multiply high quality seed in this area of the country, the question is: Why this is not being done? The seed farmers from this area replied that the main reasons were the following:

    - Seed farmers from Punjab have lost confidence in the farmers from the northern areas. At the moment of harvest, and due to the high demand for fresh potatoes at that time of the year, farmers from the northern areas would sell the potatoes to the best bidder, forgetting the initial agreement with the Punjab seed farmers. Despite this issue, seed farmers from Punjab provide fertilizers, the seed and other inputs to their counterparts in the north.

    - Many farmers leave very small tubers in the field after harvest. Thus, the following season there is a mixture of varieties. During the past 15-20 years, there has been a decrease in interest at the farmer's level on the principal concepts for high quality seed production. There is a need for training and update for new seed technologies. Farmers need to update their knowledge, e.g. seed plot techniques, on farm seed production, rouging, etc.

- There is a very loose performance of the local authorities involved in seed certification. In addition, local governments are not motivated to support this activity. However, since this area of the country is at high elevations and disease pressure is very low, only one visit by certification officers should be enough to evaluate the fields.

- As a very positive subject, it must be mentioned that the Agha Khan Foundation is actively working on those areas, trying to organize groups of good and responsible farmers. In the following recommendations this issue is further discussed.

6.3 Institutions Involved in the Process

Federal Seed Certification and Registration Department.

One of the important meetings during this assignment took place at the Federal Seed Certification and Registration Department at Islamabad. In addition to the General Director other professionals attended the meeting, including the Director of Enforcement Seed Act and the principal certification officer. The main issues that were discussed and explained were the following:

- There has been a potato seed certification protocol since 1975. However, this protocol has not been enforced in several cases because of several reasons difficult to understand, but mainly due to lack of resources (see Annex 4 for Certification Protocols).
- The seed certification is a free service provided by the government.
- The certification is only done for registered varieties.
- The registration of potato varieties involves a two-year field evaluation process. In this process, the imported seed cannot be more than one ton and it is evaluated at four locations. However, there are some loopholes in the system of importing varieties via the Plant Quarantine system which allows the importation of potato varieties without the proper evaluation.

One of the main questions to the present system is why the Seed Certification Department should be involved in variety evaluation and other procedures for imported seed. This should be, at it is in most countries, the responsibility of the National Potato Programme (they are the experts in this subject).

Punjab Agriculture Extension.

During a meeting with Dr. Muhammad Anjum Ali, Director General of the Directorate General Agriculture/Extension-Punjab, he clearly expressed his personal interest in trying to improve potato seed production in the region and decrease the amount of seed being imported. He indicated the main constraint in his department was the lack of proper training of the personnel in all technological subjects related to improving potato production. On multiple occasions, he has requested training to develop technological capabilities of staff. Contrary to other institutions previously interviewed, Dr. Anjum Ali did not mention that lack of financial support was a very important factor.

Extension services to growers in the region are greatly needed. To accomplish this, proper training to the extension personnel must take place. A training and technology transfer program should be discussed with the Extension Department. This program should involve a couple of seminars and workshop on main potato production issues, with special emphasis in those related to quality seed production, e.g. Crop management, IPM strategies, post-harvest handling of the tubers, storage concepts, farmer seed plot techniques, rouging, positive and negative selection, pesticides management and identification of main potato diseases affecting seed certification.

National Agricultural Research Center (NARC)-National Potato Programme

It is quite interesting to mention that during all the meetings with seed producer farmers, government officials and other agencies and institutions, the NARC was never mentioned, much less the existence of the National Potato Programme. This is probably the best example of the lack of articulation and national approach with reference to seed potato and potato production in general.

Normally, in most countries, it is the National Potato Programme, the Government Institution that coordinates all the issues related to potato research, production and seed production, such as research and technology transfer and development and evaluation of new varieties. It will also regulate and ensure that seed certification protocols are applied and enforced. However, in Pakistan, this is not the case.

Dr. Khalid Farooq, Seed Production Specialist from the National Potato Programme (NARC) is probably one of the most qualified local experts on potato production. He worked as the counterpart potato expert in the Collaborative Potato Projects with the International Potato Center and the Pak-Swiss Potato Development Project for several years.

During the meeting, it was evident that they are currently evaluating new potato varieties to be introduced in the country. This includes a two-year evaluation at four locations with a cost to the seed company of 15,000 Rs. per variety. The Federal Seed Certification Department is the recipient of the information, but they are not doing the evaluations.

Additionally, one of the principal mandates of the Potato Programme is to evaluate advanced genetic materials from which new varieties could be identified. The National Coordinator of the Potato Programme, Mr. Muhammad Masud Mahmood, mentioned that in 2012 they evaluated 22 varieties, and this year 13 varieties, mainly from The Netherlands. Furthermore, they are evaluating advanced lines, including 34 advanced clones, just received from the International Potato Center.

According to the Coordinator, since 2008 the coordination at the national level has weakened due to lack of financial support. They have also indicated that problems with common scab have increased (which was also indicated by PEPSICO) and there is an urgent need for research on some control measures. Finally, similar to other organizations, capacity development and training of personnel is one of their main constraints.

7 OVERVIEW OF POST-HARVEST MANAGEMENT

Similar to the seed production system, post-harvest management of potatoes is also quite different from those of the other important food crops (mostly cereals). Since potatoes are considered highly perishable as compared to cereals, they require special management to avoid heavy post-harvest losses. The same conditions also apply for the storage of potatoes.

The following actions should be taken during harvest:

1. Follow the practice of killing the haulms before harvest. This is normally done when potatoes have completed their normal physiological development and foliage is beginning to turn pale green. This practice occurs for two main reasons:
    a. To allow the skin (periderm) to complete its development
    b. To avoid later virus infection transmitted by aphids. In crops grown for seed production, vines are killed much earlier than potatoes for fresh consumption.

2. Harvest 10-15 days after killing the haulms, which can be done mechanically or chemically (e.g., Gramoxone). When cutting vines mechanically, special care must be taken to disinfect the equipment to avoid the spread of disease.

3. Always harvest in dry weather. Wet potatoes are susceptible to disease infections, especially by Erwinia spp. Under wet conditions, lenticels open up, and injuries on the skin become a magnet for disease contamination and rapid development of pathogens.

4. Avoid bruising and skinning of tubers, otherwise tubers become susceptible to rot diseases. Bruising is one of the biggest problems to be controlled during harvesting and handling of tubers. Reduce drop heights, bouncing and rolling by padding impact areas.

5. After harvest and before storing the potatoes, they must be dried and cured. Always dry the harvested tubers quickly to remove excess moisture. Tubers must be dried under shade. Expose to sun will cause the greening of tubers.
    a. Curing must be done at 23-25°C with a 95% RH. This should be done for 7-10 days.

6. When harvesting by hand, be careful not to nick and damage tubers with digger tools, and carefully transfer them to the packing shed. Never sac the tubers immediately after harvest, and never use sacs that do not allow air circulation. Using plastic sacs without holes or those that do not allow flow of fresh air will cause an increase in the internal RH, water condensation, and anaerobic conditions, which will lead to rapid rot of tubers.
7. Harvest potatoes in temperatures between 7-25°C. Harvesting potatoes at temperatures below 7°C will injure potatoes more than harvesting at higher temperatures. Also, avoid harvesting in temperature above 25°C to minimize water losses and shrinkage.

After harvest, potatoes are dormant for 6-12 weeks, depending on variety and storage conditions. After the dormancy period, potatoes may begin to sprout in storage. High temperatures will induce earlier sprouting. In cold refrigerated stores, this is controlled by keeping low temperatures. In rustic farmer stores, this could be controlled partially by using diffused light conditions.

In those places where refrigerated stores are available and where potatoes are also industrialized, store conditions will depend on the final destination of the tubers:

Intended Use of Tubers	Temperatures	Relative Humidity (%)
Table	7 C (45 F)	98
Frying	10-15 C (50-59 F)	95
Chipping	15-20C (59-68 F)	95

Source: Postharvest Technology Center-UC Davis,USA

Before storage, potatoes should be culled and cured. Cull and discard any damaged, diseased or frozen tuber.

8 INTERVENTIONS/RECOMMENDATIONS

8.1 Short Term Interventions (from 12 to 18 months)

It is highly unlikely that companies starting to produce high quality seed will be able to produce sufficient seed to replace importation and multiplication of the tubers. In the following 3-5 years, they would probably be able to replace no more than 5-10% of the seed needed nationally. Then, the only way to improve the actual system is to ensure that farmers are getting a better quality seed, and this can only be obtained by applying the certification protocols (even without government support in the beginning). In the short-term these are some of the most important items to address:

1. To develop a complete and realistic view of the current seed production system in Pakistan, it is necessary to conduct a field survey on the quality of the seed being produced at every multiplication cycle. This should be done during the autumn planting season when a large amount of potatoes is being planted in Punjab. The only system to evaluate seed quality is to field-evaluate their performance to determine disease infections and seed degeneration. This should also be done one month before harvest, in several areas of the region, and on different seed sources and varieties.

2. At the same time, there is a need to evaluate harvest and post-harvest handling of the tubers, their management, and selection of tubers that will be kept in stores. Most losses in storage are due to poor tuber handling and selection.

3. The first step in a Training Programme to be implemented should involve 1-2 days initial training on general potato and seed production technologies for 1) Farmers importing seed and famers involved in the process of their multiplication, and 2) Government personnel involved in extension and seed certification. The training must involve field evaluations on seed production and post-harvest management of tubers.

The above three items can be done during the next autumn cropping season, during the months of Jan-Feb of 2014. Field surveys should be implemented in no less than 5-7 potato fields in each of the most representative locations such as Sahiwal, Okara and three more locations. Fields with different varieties and from different seed sources should be included. Part of the surveys should be done together with certification officials as part of a training exercise.

The same should be done for the hill summer crop in the northern areas of Gilgit-Baltistan and the NWFP one month before harvest.

During the surveys, special emphasis should be placed on evaluating the incidence of scabs (powdery and or common scabs). Increasing occurrence and dissemination of these diseases is the best example of the lack of high quality seed being commercialized in the country.

The training activities should take place after the surveys in order to place special emphasis in those encountered problems.

8.2 Medium-Term Interventions (from 12 to 24 months)

The following interventions might take no less than 24 months and the initiative should start as soon as possible.

1. ASF, together with the participation of the Agha Khan Foundation, should promote the creation of farmer associations in the Northern areas of the country. This will develop a group of seed producers, who could develop a commercial relationship and potential contract with Punjab companies who need to multiply their high quality seed. Private companies starting to produce high quality seed do not need too much financial support.

   What they need is assistance from projects like TAP to collaborate with them in developing commercial agreements with potato producers in the northern areas and to multiply their high quality seed under controlled conditions. The northern areas such as Gilgit-Baltistan and NWFP should exploit their comparative advantage of agro-ecological conditions to become the regions for multiplication of high quality seed. The final beneficiary of this will be the farmers from the Punjab, producing table-fresh potatoes for the local market or for export.

2. In addition to the need to construct more potato cellars to store high quality seed, farmers and personnel involved in the certification procedures should be trained in the latest seed production technologies and certification protocols.

3. ASF could help institutions such as Hazara Agriculture Research Center to identify potential aid agencies to support their minitubers and seed multiplication efforts. This research center has already prepared a proposal that ASF could help in reviewing and improving.

4. ASF could tap some grant resources to identify and develop a couple more Tissue Culture Lab in this area. These endeavors should be combined with the effort to build more seed cellars and train innovative farmers in the seed multiplication protocols which could also be part of the overall training activities in the region to develop a SEED CULTURE among farmers.

8.3 Long-Term Interventions (from 12 to 36 months)

There is no seed production system that will succeed without the proper usage and enforcement of certification protocols. Eventually, this will have to be established in Pakistan. The use of certified seed will significantly increase potato production, and it will ensure the ability to export potatoes without any quarantine restrictions. To accomplish this, the following steps are necessary:

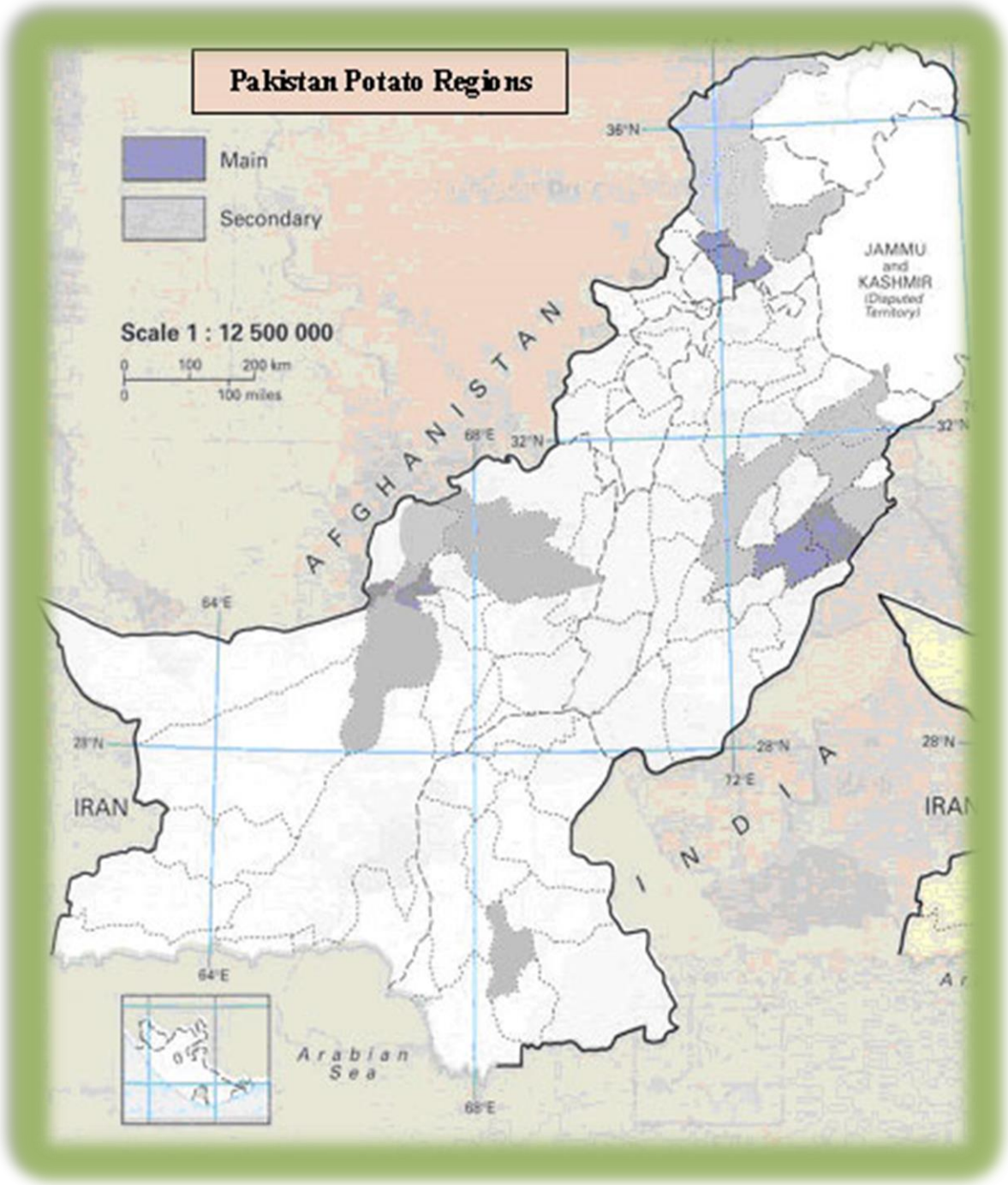
1. ASF should coordinate and sponsor a couple of meetings between the three main Government agencies involved in this process: Federal Seed Certification Department, Plant Quarantine Department and the National Potato Program.
2. Although it is not the function of ASF to work with those government institutions, it is necessary that ASF acts as a catalytic force.
3. It is mandatory to clearly establish the duties, responsibilities and area of action of those three Government institutions to avoid loopholes in the system.
4. Later on, ASF could send a summary of the decisions made through the proper channels to the Ministry of Agriculture, indicating the need for those changes since all countries worldwide require and need potato seed certification protocols and its strict enforcement of its regulations to have an effective and competitive potato value chain.

8.4 Summary of Principal Interventions / Recommendations

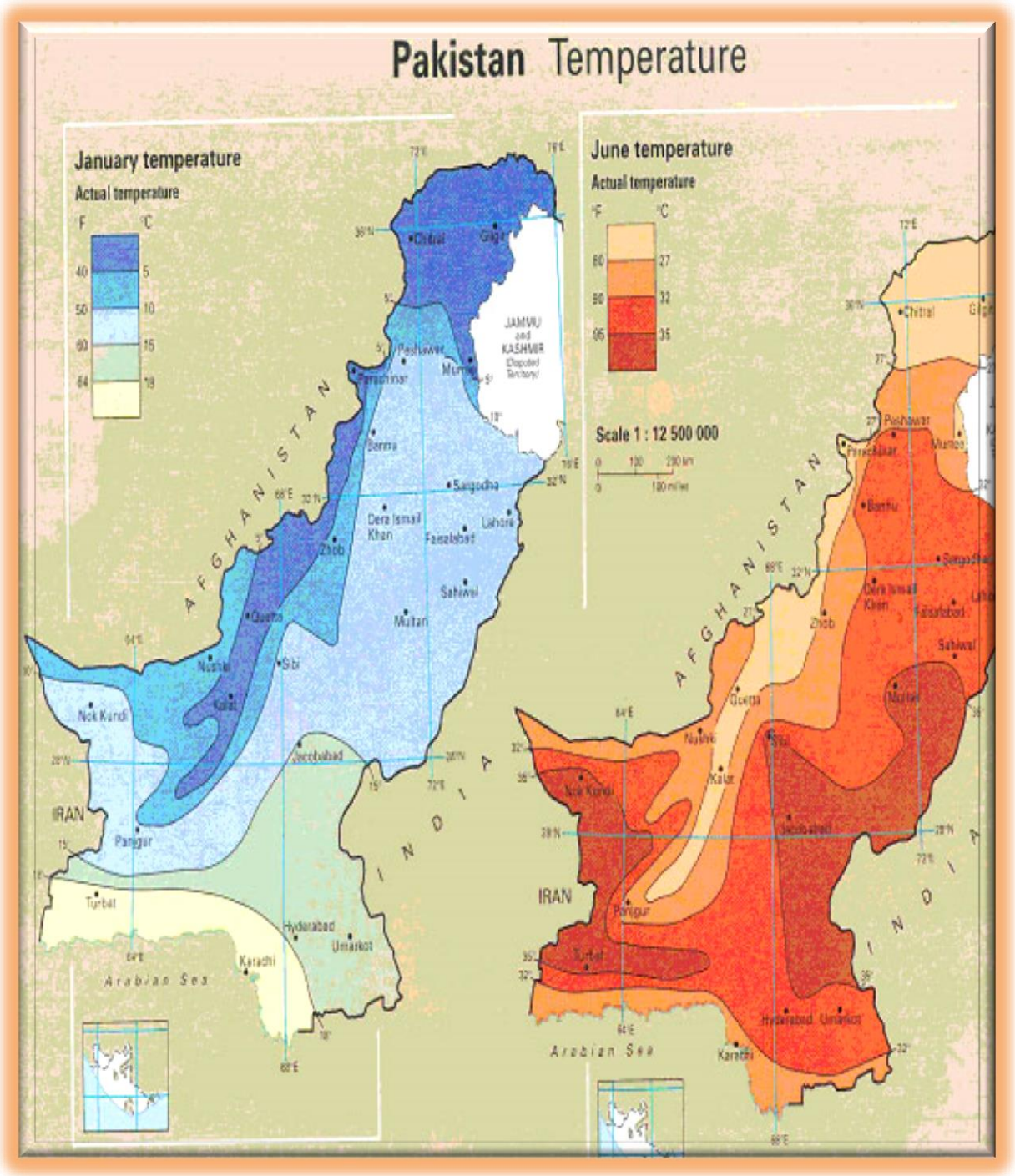
TIMING	PUNJAB REGION	NORTHERN AREAS
Short-Term **(12-18 months)** To complete surveys on seed quality. Training on seed production and technology update	**Jan/Feb 2014:** **- Field surveys:** a) Seed quality b) Post-Harvest management c) Scab occurrence **- Training:** a) Seed farmers b) Extension and Certification personnel c) Seed producers	**Aug/Sept 2014:** **- Field Surveys:** a) Seed quality b) Post-harvest management c) Scab occurrence **- Training:** a) In-Vitro Labs & Minituber production update b) Seed Multipliers c) Extension & Certification personnel
Medium-Term **(12-24 months)**	- Seed producers to develop agreements to multiply high quality seed with farmer´s groups in Northern areas. - When needed, continue training activities and development of a Seed Culture.	- Coordinate with Agha Khan Foundation to develop strong farmer´s groups to multiply seed for Punjab seed producers. - Provide support to existing/new tissue culture labs to produce minitubers and their further multiplication. - Provide support to construct more seed potato cellars to store high quality seed.
Long-Term **(12-36 months)**	**In Islamabad:** - Coordinate meetings with government agencies to define responsibilities on seed certification, variety evaluation, introduction and registration. - Present to Ministry of Agriculture the need for changes.	

9 ANNEXES

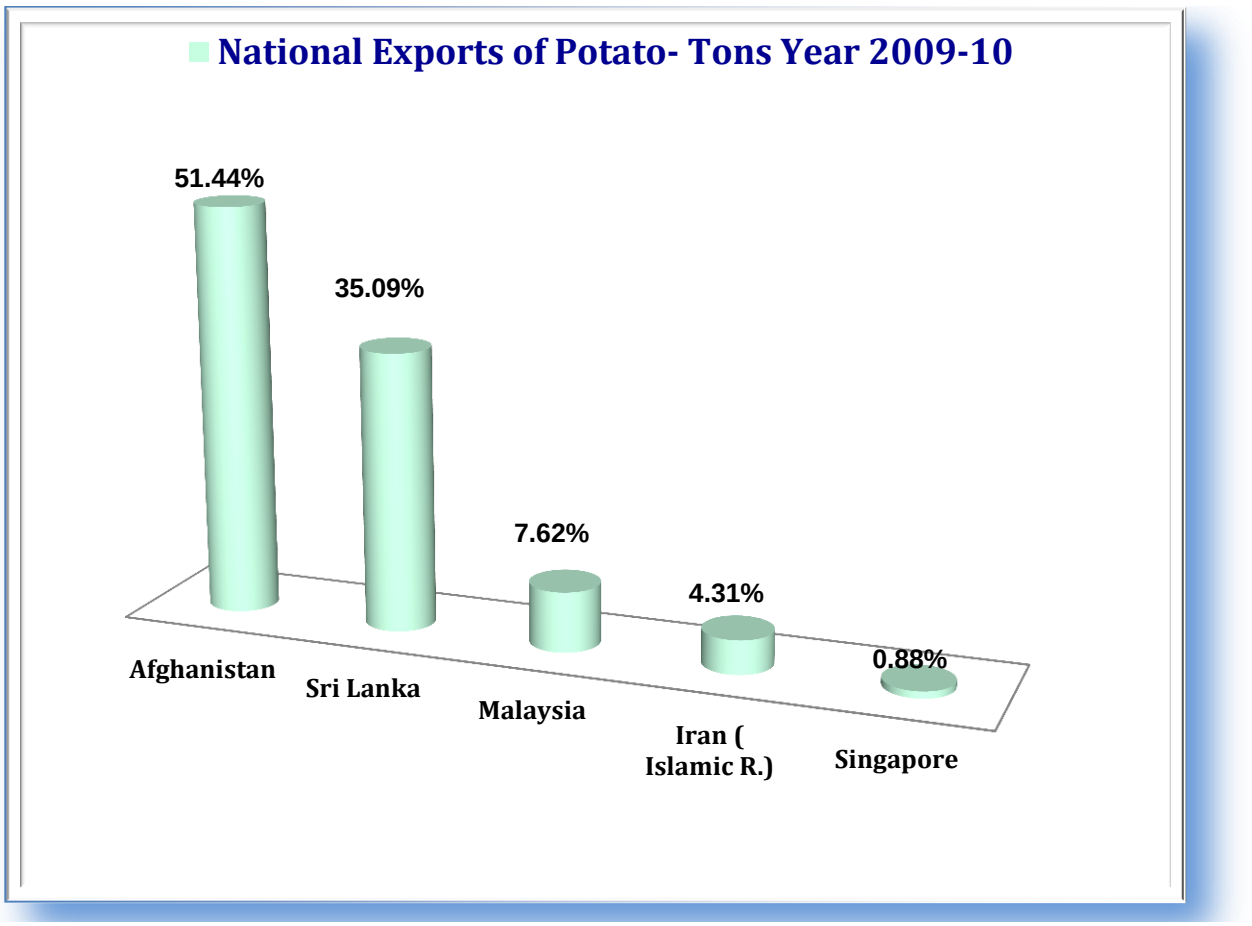
9.1 Annex 1 Main Potato Producing Zones in Pakistan



9.2 Annex 2 Summer and Winter Temperatures in Pakistan



9.3 Annex 3 Potato Exports From Pakistan



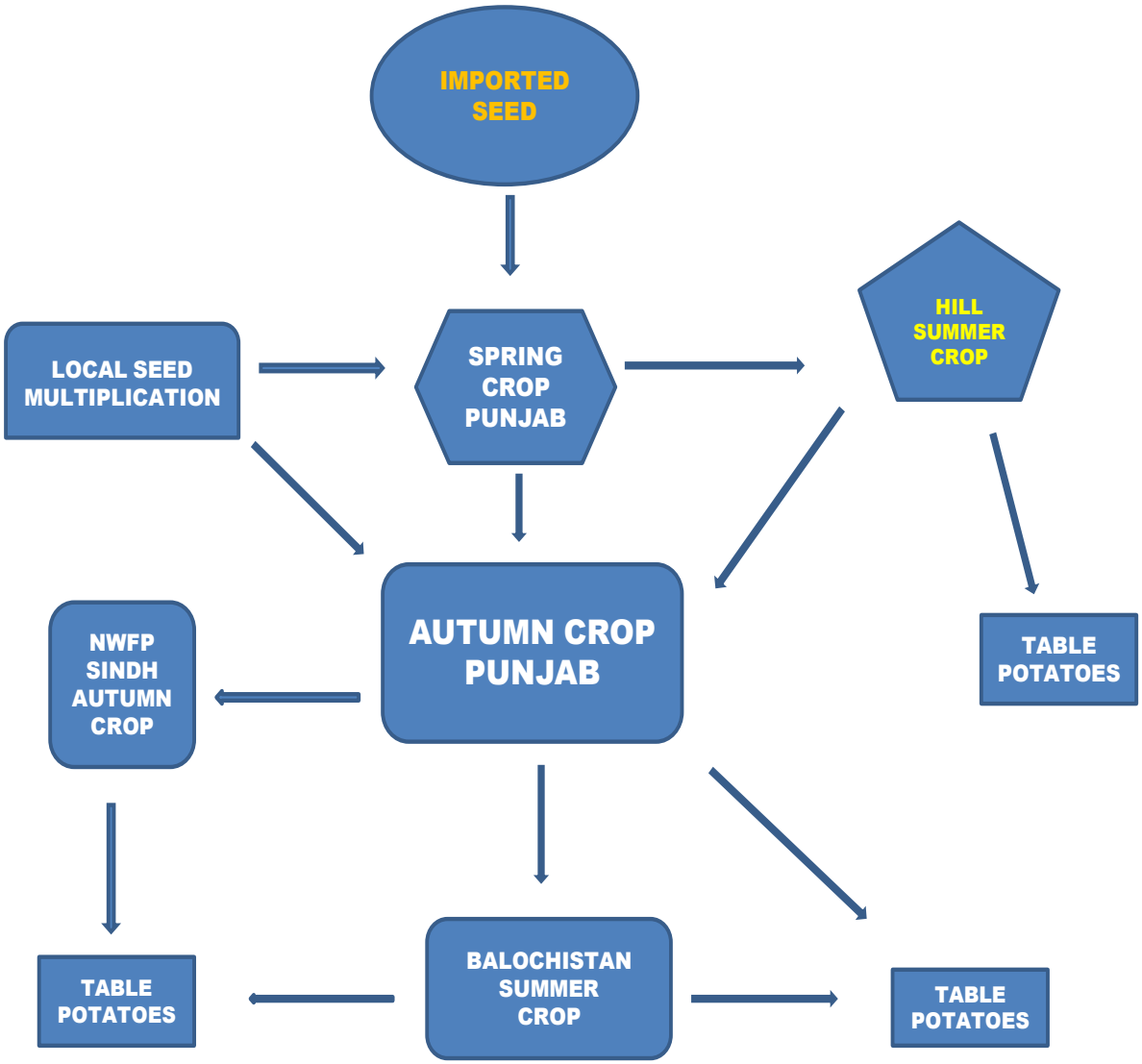
Source: Dr. Babar Bajwa (ASF) - Potato Supply Chain in Pakistan

9.4 Annex 4 Institutions Engaged in Production of Minitubers

(as part of a Rapid Multiplication System for Certified Seed Production in Pakistan as of 2004)

INSTITUTION	CURRENT MINITUBERS PRODUCTION (NUMBER)	POTENTIAL MINITUBER PRODUCTION (NUMBER)
NARC, Tissue culture Lab., Islamabad	30,000	100,000
Ayub Agri. Research Inst. Plant Virology, Islamabad	50,000	150,000
Punjab Seed Corporation, Sahiwal	80,000	80,000
Potato Seed Unit, Dept. of Agric., Gilgit	150,000	150,000
Potato Research Center, Abbottabad	40,000	250,000
VSSPP, Balochistan	15,000	20,000

9.5 Annex 5 Simplified Potato Seed Production/Multiplication in Pakistan



9.6 Annex 6 Certification Protocols and Standards for Potato Seed Certification

Every country has different seed certificate standards. These standards are framed according to agro-climatic farming systems. The following seed certification standards are being enforced in Pakistan.

Field Standards and their Maximum Permitted Percentage

Factors	Stages	Pre Basic I	Pre Basic II	Basic I	Basic II	Certified
Off type*	2nd inspection	None	None	0.5	0.5	0.5
PVY		None	None	0.5	0.5	0.5
PLRV		None	None	0.5	0.5	0.5
PVX/PVA		None	None	0.5	0.5	2.0
Other viral diseases		None	None	0.5	0.5	2.0
Maximum of all viral diseases		None	None	1.0	2.0	4.0
Fusarium Wilt		None	None	0.2	0.5	1.0
Black Leg		None	None	0.5	0.5	1.0
Rhizoctonia, leaf curl & mild verticillium		None	None	5.0	5.0	10.0
Severe Verticillium	At 2nd & 3rd inspection	None	None	1.0	1.0	3.0
Brown Rot	At 2nd & 3rd inspection	None	None	None	None	None
Ring Rot	At any stage	None	None	None	None	None
Early Blight	At any stage: Only Relevant If Masking Other Diseases					
Late Blight	At any stage: Haulm Must Be Destroyed Immediately					

*Off type does not exceed 2%, rouging can be recommended during first inspection.

Seed Potato Standards (tubers) and Maximum Permitted Percentage

	Factors	Pre Basic II	Basic I	Basic II	Certified I	Certified
1	Other Varieties	None	None	0.2	1.0	2.0
2	Soil & inert matter. Cut, bruises, % malformed	N.A.	0.5	1.0	2.0	3.0
3	Dry Rot	None	None	0.5	1.0	2.0
4	Wet Rot	None	None	None	0.2	0.5
5	Rot due to late & early blight	None	None	None	None	None
6	Rhizoctonia**	None	0.5	0.5	1.0	2.0
7	Common Scab***	None	None	0.5	1.0	2.0
8	Brown Rot, Ring Rot	None	None	None	None	None
9	Wart	None	None	None	None	None
10	Powdery Scab	None	None	None	None	None
11	Black Leg	None	None	None	0.5	1.0
12	Size of Tuber ****					
	Hill	N.A.	33-65 mm	33-55 mm	33-55 mm	33-55 mm
	Plain	N.A.	30-45 mm	30-45 mm	30-45 mm	30-45 mm

* Minimum permitted % age for Sr. No. 1 to 10 shall not exceed 5% for certified – 1 and 10% for Certified 2
**Rhizoctonia with more than 1/20th of surface of tubers covered by sclerotia will be rejected
*** Common scab with more than 1/20th of surface of tuber covered by scab will be rejected
**** Size of tuber 5% (+,-) of the given standard will be accepted

Potato

1. The size of the seed potato shall be 30/60 mm.
2. The tuber shall be reasonably cleaned, healthy and firm with colour and shape distinct for variety. Three (3) percent admixture of other varieties shall be permisible.
3. Mechanical damage i.e. cuts, injuries, bruises, cracks shall be permissible only up to five (5) percent level.

The following percentage shall be permitted for visible symptoms caused by:

	Maximum Permitted %
Rhizoctonia	2%
Wart	None
Brown Rot	None
Powdery Scab	0.5%
Common Scab	2%
Black Leg	1%
Wet Rot	1%
Late Blight	2%
Fusarium & Verticillium spp.	2%

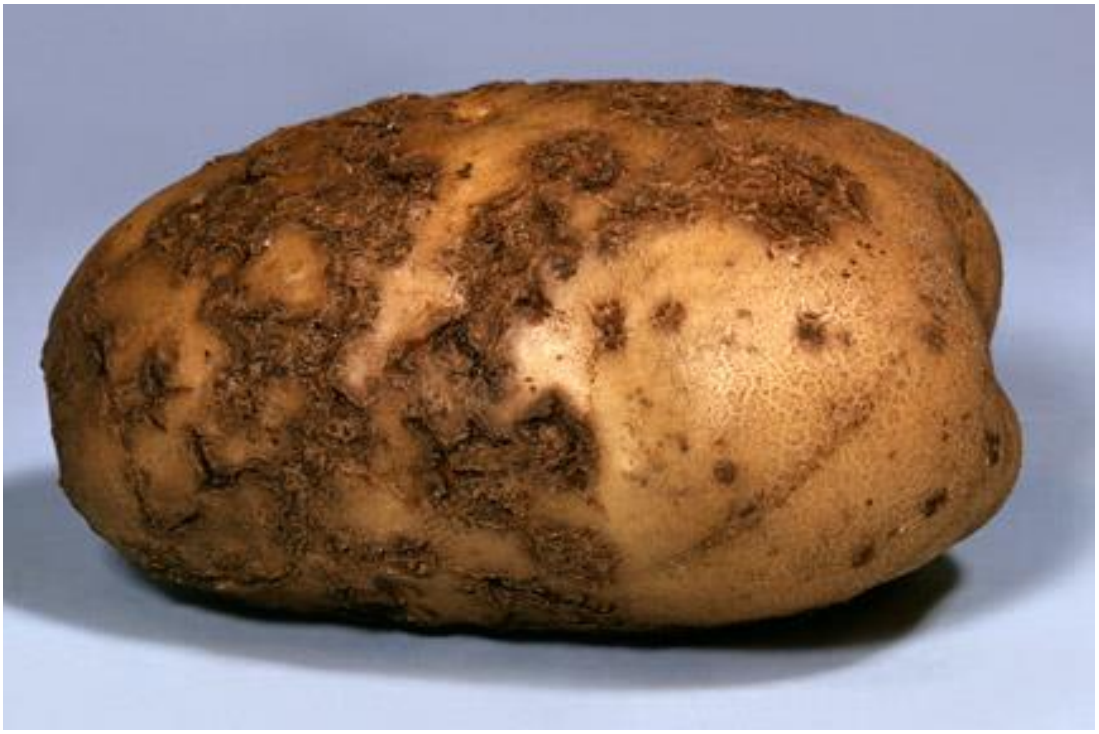
9.7 Annex 7 List of Some of the Institutions and People Interviewed

1. Tahir Saleemi (Haji Sons). Lahore. Seed Production
2. Afzaal Haider Rizvi (Rizvi Farms). Okara. Seed Production
3. Zardae Zahid Shuja . Okara. Seed production
4. Rafi Mansoor Bajna. Okara. Seed Production
5. Muhammad Anjum Ali. Director General, Agriculture Extension-Punjab
6. Mian Munir, Director Institute of Agriculture Marketing- Punjab
7. Ch. Muhammad Tariq. Regional Director of Seed certification-Punjab
8. Hakim Khan (ASF). Horticulture Value Chain Specialist- NWFP-Peshawar
9. Zaheer Ullah Khan. Director Hazara Agriculture Research Station-Abbottabad
10. Asif ur Rehman Khan. Plant Pathologist, Hazara Research Station-Abbottabad
11. Shaid Iqbal. Director General Federal Seed Certification &Registration-Islamabad
12. Iftikhan Haider. Deputy Director Federal Seed Certification & Registration-Islamabad
13. Khalid Mahmood. Director of Enforcement Seed Act. Certification-Islamabad
14. Abid Bukhari. Ex-Manager PepsiCo Potato Seed Production(Lahore)-Islamabad
15. Khalid Farooq, National Potato Programme, Islamabad (with Gilgit group)
16. Niaz Mohammad Jamal, Hazar Agro Seed Company, Mansehra (Gilgit group)
17. Abdul Khabir, Regional Program Manager-ASF, Gilgit, Baltistan (Gilgit group)
18. Almagir – Agha Khan RSP, Gilgit (Gilgit group)
19. Anwar khan, Jabbar Seeds Intl. (Gilgit group)
20. Gul Munir, Nanga Parbat Seed Co., Gilgit-Baltistan (Gilgit group)
21. Javed Ullah, Mountain Seed (Pvt), Gilgit-Baltistan (Gilgit group)
22. Obaid Ur Rechman. Zamira Seed Corporation, Okara (Lahore)
23. PEPSICO Technical staff and Farmers (9 people in total)
24. Muhammad Masud Mahmood, National Coordinator of the NARC´s Potato Programme

9.8 Annex 8 List of Main Documents Reviewed

1. Horticulture (Peaches, Dates, Potatoes, Chilies) Value Chain Assessment Final Report for USAID Agribusiness Project- CNFA/ASF. Rupert Knowles. December 2012.
2. Strengthening Potato Value Chain. Technical and Policy Options for Developing Countries. FAO Report, Rome 2010.
3. Seed Potato Systems in Pakistan. A. Hussain & K. Farooq. Pak-Swiss Potato Potato Development Project, NARC, Islamabad, 1995.
4. Potato Value Chain Evaluation on the NWFP-Kashmir of Pakistan. Report from CNFA Consultant M. Connaughton, 2007.
5. Potential Markets of Potato. M. A. Khan & Sahid L. Khan. Trade Development Authority of Pakistan, Islamabad. 2010.
6. Pakistan. World Potato Atlas. International Potato Center, Lima (Peru).2010
7. ILED Aiding Agriculture in Pakistan's Earthquake Hit Regions. USAID-CNFA/I-LED Project. 2007-2009.
8. Potato Supply Chain in Pakistan. Babar Bajwa. The Agribusiness Project. USAID/ASF. 2013.
9. Pakistan. Min. of Commerce. Horticulture Development & Exports. Potato. 2005
10. In PaperMagazine (2013). Potato Export Resumes after 2 year gap.
11. www. FAOSTAT.org
12. www.Statpak.gov.pk
13. Bayer Crop Science. Pakistan. Potato 2009.
14. Cool chain and post-harvest sector in Pakistan (2013). Chris Bishop. Report of Consultancy, USAID-CNFA/ASF.

9.9 Annex 9 Photos of Potato Scabs



Common Scab (*Streptpmyces scabies*)

Powdery Scab (*Spongospora subterranean*)

9.10 Annex 10 Minituber Production Using Two Different Technologies

9.11 Annex 11 Minituber production at Hazara Agriculture Research Center-Abbottabad

9.12 Annex 12 Potato Variety Evaluation at Hazara Agriculture Research Center-Abbottabad

9.13 Annex 13 Table Potatoes on the Road to Haripur-Abbottabad

9.14 Annex 14 Estimated Budget for Field Assessment of Seed Quality and Post-Harvest Management of Seed in the Punjab Region – Jan/Feb. 2014

OBJECTIVES:

1. Determine potato seed quality being planted in the Punjab.
2. Estimate percent of principal diseases.
3. Determine the most important factors affecting the field production.
4. Assess the harvest procedures being used.
5. Determine main causes for post-harvest losses.
6. Assess the principal types of potato storages being used by farmers.
7. Develop a practical guideline to improve seed quality and reduce post-harvest losses.
8. Provide field observations and validation for the training workshop to be conducted for seed farmers, seed importers, and extension and certification officers of the Punjab Province.

ACTUAL FIELD WORK

- 15 days of field work
- At least 5-7 fields at Okara, Sahiwal, Pakpattan, Kasur
- Field with different varieties and at different multiplication cycle
- A form will be developed to collect data
- A final report will be prepared to improve seed quality and post-harvest management
- Evaluations to be done:
  - ✓ Main diseases present
  - ✓ Percent of incidence in each field
  - ✓ Determine type of scab and incidence
  - ✓ Determine estimation of seed quality
  - ✓ Determine yield from each potato field
  - ✓ Type of tuber handling
  - ✓ Selection procedures for tubers being kept for storage
  - ✓ Harvest procedures and management
  - ✓ Determine post-harvest damage
  - ✓ Determine source of principal post-harvest damage

ESTIMATED BUDGET:

A. Consultant fees for 15 days (15 x USD 500)	USD 7,500
B. Consultant Per diem for 15 days (15 x USD 300)	USD 4,500
C. Transport for survey, including driver	USD 1,500
D. Other materials needed	USD 500
E. International transport to Pakistan**(*)**	USD 3,000
TOTAL……	**USD 17,000**

(*) = This also includes the international transport for the Training Activities since the same specialist in Plant Protection and Seed Production will be doing both assignments**.**

9.15 Annex 15 Estimated Budget for Training Workshop on Seed Quality, Certification Protocols and Post-Harvest Handling of Tubers

The main objective of the training workshop is to get seed farmers and government officers acquainted with the basic concepts of seed production and on how to improve quality seed even though certification protocols are not fully implemented by the local certification authorities.

The training workshop should be a 1-day theoretical class room session, followed by a day of field visits to apply the main concepts discussed the first day. The training should take place at two diverse locations that represent the main seed potato producing areas in the Punjab (e.g., Okara and Sahiwal).

The principal topics that should be included in the training are the following, but not restricted to other related issues:

1. Concepts on vegetative propagation
2. Case of potatoes and need for clean initial stocks
3. Types of seed production schemes
4. Basic concepts on seed selection
5. Positive and negative selection
6. Seed selection at farmers' level
7. Seed Plot techniques applied to farmers' fields
8. Main diseases affecting potato production
9. Concepts of rouging out
10. Basic schemes for seed production
11. Basic protocols for seed certification
12. Handling tubers at harvest
13. Importance of tuber selection for storage
14. Main reasons for post-harvest losses
15. How to prevent post-harvest losses
16. Different types of potato storage
17. Means to break dormancy in potato tubers

Estimated Cost of a 2- Day Training Course in One Location in the Punjab Region

Description	No of Persons	Unit cost	Days/ frequency	Total Cost Rs.
Accommodations and Travel	15	4,000	2	120,000
Flexo banners, photography, etc.			2	15,000
Training Hall, Refreshment (Lunch, tea, cookies) and other charges	Lump sum	75,000	2	150,000
Training materials (includes technical materials/training manual, stationary, certificates, branding & marking)	15	4,000	1	60,000
Field Visit Travel Cost	15	75,000	1	75,000
Miscellaneous			-	50,000
Total Cost				**470,000**

Estimated cost in USD: $4,810 (1USD: 97.7 PKR)

*These costs do not include fees for the seed production expert.